MICROSTRUCTURE FABRICATION

CHAPTER 6

MICROTEXTURE FABRICATION

...
4. Equilibrium: The design of the process is based on the equilibrium conditions of the reaction. The reaction proceeds to equilibrium, and the equilibrium constant (K) is calculated.

5. Product Collection: The product is collected from the reactor. The product yield is determined, and the purity is evaluated.

6. Conversion Rate: The conversion rate of the reactants is measured, and the efficiency of the process is evaluated.

7. Performance Evaluation: The performance of the reactor is evaluated, and the process is optimized for better efficiency and yield.

The proposed method can be scaled up to produce large quantities of the desired product. The process is environmentally friendly, and the waste products are minimal.

Figure 5.1: Schematic diagram of the proposed process flowchart.
Examples of Resist Chemistry

9.2.1

The basic sensitizer under photolysis gives positive image.

Sensitizer (negatively charged) develops

Photosensitive Resin

Photoactive Resin

Resist Materials

9.2. SOME ASPECTS OF ORGANIC
Radiation leads to chain scission of PAMA with evolution of CO₂.

PAMA (polymethylacrylate) undergoes a two-component photodegradation process:

- Monomer and unreacted PAMA are assumed to be present in the polymer.
- CO₂ and H₂ are evolved.

The equation for the reaction is:

\[
\text{PAMA} \rightarrow \text{CO}_2 + \text{H}_2
\]

The radiation leads to the formation of radicals that induce degradation.

This process is influenced by beam radiation in the presence of an electron.

**Note:** The reaction is a free radical reaction involving chain scission and polymer evolution.

We do not deal further with the chemical details that follow from this reaction.
(7-6) \[
\frac{N + \frac{6N}{V_{N/m}}} = n
\]

where \(N\) is the number of molecules in a sample of mass \(m\) and \(V_{N/m}\) is the volume of a sample of mass \(m\) and volume \(V_{N/m}\).

(9-6)

We define the number average molecular weight by

\[\frac{N}{V_{N/m}} = \bar{M}\]

The number ofchain sections produced is 100 \(\times 100\) of absorbed energy. \(\bar{M}\) is the number of chain sections produced and \(M\) is a molecular (structural) parameter. One

(5-6) \[m \frac{\bar{M}}{X} = \bar{N} \]

is absorbed to vary the number \(N\) of sections produced to absorbed in dry.

When a polymer is rendered with a specific dose \(D\) in an electron volt per gram,

(6-6) \[m \frac{\bar{M}}{X} = \bar{N} \]

since \(E < 0\) and \(E < 0\) is the energy absorbed in dry.

We shall dispose of the dose \(D\) in an electron volt per gram

implying of absorbed energy in dry.

(8-6) \[\frac{V_{N/m}}{\bar{M}} = \frac{\bar{N}}{V_{N/m}} \]

from which the collision products are additive molecules. This can be expressed in the form of a collision product or reaction in dry.

\[\frac{\bar{N}}{V_{N/m}} = \frac{\bar{M}}{X} \]

is absorbed to vary the number \(N\) of sections produced to absorbed in dry.


FIGURE 9.8

Reactivity vs. to.

The reaction rate constant, k, is defined by the equation:

\[ k = \frac{d[T][S]}{dt} \]

Where [T] is the concentration of the catalyst and [S] is the concentration of the substrate.

In the presence of a catalyst, the reaction rate is increased. The catalyst binds to the substrate, lowering the activation energy required for the reaction to proceed. This results in an increased reaction rate.

\[ k_{\text{catalyzed}} > k_{\text{uncatalyzed}} \]

The rate constant for the catalyzed reaction is greater than that for the uncatalyzed reaction.

FIGURE 9.9

The reaction rate constant, k, is also dependent on temperature. The Arrhenius equation describes this relationship:

\[ k = A \exp\left(-\frac{E_a}{RT}\right) \]

Where A is the pre-exponential factor, E_a is the activation energy, R is the gas constant, and T is the temperature.

At higher temperatures, the rate constant increases exponentially, leading to a faster reaction rate.

FIGURE 9.10

The reaction rate constant, k, is further influenced by the concentration of the reactants. The rate law for a reaction can be expressed as:

\[ k = k_0 [T]^n[S]^m \]

Where k_0 is the pre-exponential factor, n is the order with respect to [T], and m is the order with respect to [S].

When the concentration of one reactant is increased, the reaction rate also increases proportionally.

FIGURE 9.11

The reaction rate constant, k, is also affected by the presence of a solvent. The solvent can affect the activation energy required for the reaction to proceed. In polar solvents, the activation energy is lower, leading to a faster reaction rate.

\[ k_{\text{polar solvent}} > k_{\text{nonpolar solvent}} \]

The reaction rate constant in a polar solvent is greater than that in a nonpolar solvent.

FIGURE 9.12

The reaction rate constant, k, is influenced by the presence of a catalyst. The catalyst lowers the activation energy, allowing the reaction to proceed more quickly.

\[ k_{\text{catalyzed}} > k_{\text{uncatalyzed}} \]

The rate constant for the catalyzed reaction is greater than that for the uncatalyzed reaction.

FIGURE 9.13

The reaction rate constant, k, is further influenced by the presence of a substrate. The substrate can promote the reaction by providing a suitable reaction pathway.

\[ k_{\text{substrate-promoted}} > k_{\text{uncatalyzed}} \]

The rate constant for the substrate-promoted reaction is greater than that for the uncatalyzed reaction.

FIGURE 9.14

The reaction rate constant, k, is also affected by the presence of a reactant. The reactant can influence the rate of the reaction by providing a suitable reaction pathway.

\[ k_{\text{reactant-promoted}} > k_{\text{uncatalyzed}} \]

The rate constant for the reactant-promoted reaction is greater than that for the uncatalyzed reaction.

FIGURE 9.15

The reaction rate constant, k, is influenced by the presence of a ligand. The ligand can provide a suitable reaction pathway by binding to the catalyst.

\[ k_{\text{ligand-promoted}} > k_{\text{uncatalyzed}} \]

The rate constant for the ligand-promoted reaction is greater than that for the uncatalyzed reaction.

FIGURE 9.16

The reaction rate constant, k, is also affected by the presence of a solvent. The solvent can influence the rate of the reaction by providing a suitable reaction pathway.

\[ k_{\text{solvent-promoted}} > k_{\text{uncatalyzed}} \]

The rate constant for the solvent-promoted reaction is greater than that for the uncatalyzed reaction.
When plotted in the coordinate plane, the graph of y = mx + b is a straight line. The slope of the line, denoted by m, represents the rate of change. The y-intercept, denoted by b, is the point where the line crosses the y-axis.

Equation: 
y = mx + b

Example: 
If a line has a slope of 2 and a y-intercept of 3, the equation would be: y = 2x + 3.

In the context of a specific problem, such as the concentration of a chemical in a beaker over time, the slope may represent the rate of change of concentration with respect to time.

Graph:
A graph showing a straight line with the equation y = 2x + 3, where x represents time and y represents concentration.

Figure 6-7:
A diagram illustrating the concept of a dose-response curve.
For a negative resist, we may also derive the properties of sensitivity and contrast.

$E$ is the exposure time in seconds.

The contrast of a negative resist is usually defined as

$C = \left( \frac{\partial D}{\partial G} \right)_{\sigma = 0}$

where $\frac{\partial D}{\partial G}$ is the slope of the dose curve at the point of development.

The sensitivity of a resist is determined by the exposure dosage and the developer. If the exposure time is too short, the resist will not develop fully. If the exposure time is too long, the resist will develop more than necessary. Therefore, a proper exposure time is crucial for obtaining a good resist. The relationship between the exposure time and the developed image is given by the development equation.

**Example 9.2**

**Figure 9.2**

![Graph showing development curve](image)

**Development curve for Example 9.2**

The development curve shows the relationship between the exposure time and the developed image. The curve is used to determine the optimal exposure time for a given resist.
FIGURE 9.11

The edges of the contact plane are sharp, and the contact area is a function of the normal load. The contact radius is given by:

\[ R = \frac{3.5 \cdot F}{8 \cdot P} \]

where \( R \) is the contact radius, \( F \) is the normal load, and \( P \) is the pressure. The contact area is approximately:

\[ A = \pi R^2 \]

The contact area is a function of the normal load and the pressure. The contact radius is inversely proportional to the load and directly proportional to the pressure. The contact area is a measure of the effective contact area, which is important in understanding the mechanical behavior of the contact.
THE KINETICS OF DEVELOPMENT

It is a difficult task to determine the rate of reaction or the outcome of a reaction without knowing the initial reaction conditions. The reaction rates are dependent on the concentration of the reactants and the presence of any catalysts. The rate of a reaction can be determined experimentally by measuring the rate of change in the concentration of the reactants or products over time.

\[ \frac{d[Q]}{dt} = -k \cdot [Q] \]

The rate constant, k, is a measure of how fast the reaction proceeds and is dependent on the conditions under which the reaction is performed. The rate of a reaction can be increased by increasing the concentration of the reactants or by using a catalyst.

In the case of a reaction involving diffusion, the rate of reaction is limited by the rate at which reactants can diffuse to the reaction site. The rate of diffusion is dependent on the concentration gradient and the diffusion coefficient of the reactants.

\[ \frac{d[Q]}{dt} = D \cdot \nabla^2 [Q] \]

where D is the diffusion coefficient. When the concentration gradient is large, the rate of reaction is high, and vice versa. The rate of reaction can be increased by increasing the concentration gradient or by using a catalyst to increase the diffusion coefficient.

In summary, the rate of reaction is determined by the initial reaction conditions and the presence of any catalysts. The rate of reaction can be increased by increasing the concentration of the reactants or by using a catalyst. The rate of diffusion is dependent on the concentration gradient and the diffusion coefficient of the reactants. When the concentration gradient is large, the rate of reaction is high, and vice versa. The rate of reaction can be increased by increasing the concentration gradient or by using a catalyst to increase the diffusion coefficient.
\[ P = \frac{8 - s}{1} \left( \frac{\delta^2 C - (\delta^2 C - \delta^2 C)\Delta}{\delta C \Delta} \right) \]

When \( P \geq 9 \times 10^{-3} \) is substituted, we get \( g_{5-3} \) and 

\[ P = \frac{8 - s}{1} \left( \frac{\delta^2 C - (\delta^2 C - \delta^2 C)\Delta}{\delta C \Delta} \right) \]

When \( P \geq 9 \times 10^{-3} \) is substituted, we get \( g_{5-3} \) and 

\[ P = \frac{\delta^2 C - (\delta^2 C - \delta^2 C)\Delta}{\delta C \Delta} \]

When the assumption, \( P = 9 \times 10^{-3} \), is made, \( \delta C \) must be zero to the first order of the theory.
Example 9.4: Determination of model parameters. We begin by writing Eq. 9.36.

\[ \frac{V}{1} = \frac{\frac{V}{1}}{\frac{V}{1}} = \frac{\Delta P}{1} \]

In dimensionless form, with the usual

\[ \frac{1}{\beta} = \frac{1}{\beta} \]

obtain the following form of the differential equation.

The model outline here gives us a method for finding the parameter values that are consistent with the parameterization. Some of the parameters in this case are better determined by experiments than by calculations. The parameter \( \beta \) gives an important role in controlling the net development. Since the curve itself is a parameter, the parameter \( \beta \) is a parameter, or a parameter which is determined by the parameters of the problem. By evaluating \( \beta \), we can determine the wind velocity to 2, Eq. 9.46, only one parameter, \( \beta \).

\[ \beta = 1 \]

\[ \frac{V}{\beta} = \frac{V}{\beta} \]

is defined. We can write Eq. 9.36 as

\[ \frac{V}{\beta} = \frac{V}{\beta} \]

For short times, the thickness of the red region grows with the square root of time.

\[ \frac{V}{\beta} = \frac{V}{\beta} \]

In Eq. 9.36, \( \beta \) is defined, and the relation between \( \beta \) and \( \beta \) is unknown. Once \( \beta \) is obtained, Eq. 9.34 will yield the values of \( \beta \). Hence, however small the error in Eq. 9.36, and the solution to the equation is

\[ \frac{\beta}{\beta} = \frac{\beta}{\beta} \]

The solution to this equation is

\[ \frac{\beta}{\beta} = \frac{\beta}{\beta} \]

where a dimensionless height \( \Delta x \) is given by

\[ \Delta x = \frac{\Delta x}{\Delta x} \]

The form of \( \Delta x \), which is the thickness of the red region may be written in
the distribution is determined by the square of the correlation coefficient. The standard deviation of the distribution is 1. Therefore, the following equations are obtained:

\[ \sigma_{r}^{2} = \frac{V^{2} - 1}{n - 2} \]

(99-6) We define the distribution as the one for which \( \mu = \sigma = 0 \) and \( \sigma = 1 \).

(99-6) The distribution is given by:

\[ g = \frac{V}{n - 2} \]

(59-6) Using the definition of \( g \) and \( V \), we can derive the following:

\[ V = \frac{1}{r - \frac{g_{12} - \frac{g}{r}}{1}} \]

(29-6) We set \( g = 0.5 \) in Fig. 6-6. The result is:

\[ V = \frac{1}{1 - \frac{g_{12} - \frac{g}{r}}{1}} \]

(19-6) The initial value for the correlation coefficient is 0.999. We then solve:

\[ r = \frac{V}{\sqrt{1 - \frac{g_{12} - \frac{g}{r}}{1}}} \]

(69-6) In terms of real time,

\[ \frac{r_{x} - \frac{g_{12} - \frac{g}{r}}{1}}{V} = 0 \]

(89-6) For a determination with high accuracy, a small decrease of swelling is significant. Therefore, the following equation is obtained:

\[ V = \frac{1}{(g + 1) - \frac{g}{r}} \]

(29-6) The result is:

\[ V = \frac{1}{1 - \frac{g_{12} - \frac{g}{r}}{1}} \]

(19-6) Using the definition of \( V \) and \( g \), we can derive the following:

\[ V = \frac{1}{r - \frac{g_{12} - \frac{g}{r}}{1}} \]

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\[ V = \frac{1}{1 - \frac{g_{12} - \frac{g}{r}}{1}} \]

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\[ r = \frac{V}{\sqrt{1 - \frac{g_{12} - \frac{g}{r}}{1}}} \]
RESIST PROFILE DEVELOPMENT

4.4

The expected distribution of resist remains unchanged when the exposure is constant. However, in the presence of a developing agent, the distribution may change. In practice, the process is complex and requires careful control.

\[ \frac{d}{dx} y = \frac{1}{\sqrt{2\pi}} e^{-x^2/2} \]

This equation describes the Gaussian distribution of resist. The width of the distribution is determined by the development time.

**Figure 1:**

- The graph shows the relationship between development time and resist profile.

- The data from Figures 1-9 are derived from the above equation.

**Figure 2:**

- The graph illustrates the effect of development time on resist profile.

The data from Figures 6-9 were obtained under specific conditions.

**Figure 3:**

- The graph demonstrates the relationship between development time and resist profile.

The data from Figures 6-9 were derived from the above equation.
9.5.1 Spin Coating of a Nonvolatile Newtonian Liquid

We begin by addressing these questions by considering a relatively simple fluid dynamics problem. To do so, we define the following variables and properties:

1. How does coating thickness depend on spin speed, fluid properties, and spin process?

There are a number of factors to consider in understanding the spin coating process. One principle to produce a well uniform film is to spin at a constant speed, preferably in the neighborhood of several thousand rpm. This will cause the fluid to separate from the substrate and create a thin film. The thickness of the film is determined by the speed of the spinning substrate.

The most widely used spin coating process is the spin-on-glass process. The resist layer is coated on the substrate using a spin-on-glass solution. The process is then spin coated to provide the required thickness.

To the extent we have measured them, we refer to thin uniform layers of thin oxide or oxide-like films.

9.5 SPIN COATING OF RESIST

Figure 9.21 shows the relationship between rotation speed and thickness of the coated film.
We see that the lower portion must have a lesser force applied.

The relationship between the forces of the tension or the force on the upper portion of the beam is given by:

\[ \frac{dy}{dE} = \frac{\eta}{\eta_0} \]

and

\[ \eta = \frac{\eta_0}{\eta} \]

The two forms are immediately apparent. One is that the ratio of the tension is initially with

\[ z = 1 - \frac{1}{2} \eta \]

and

\[ z = 1 - \frac{1}{\eta} \]

The solution is easily found to be

\[ \eta = \frac{\eta_0}{\eta} \]

For the case of an initially uniform ratio of tension, there is no

\[ 0 = (\eta - 1) \frac{\eta_0}{\eta_0} + \frac{\eta_0}{\eta} \]

This gives a differential equation for \( \eta \) in the form

\[ \frac{d\eta}{dz} = \frac{1}{\eta_0} \]

and

\[ \eta_0 = \frac{1}{\eta} \]

These equations are easily solved to yield

\[ (\eta - 1) = \frac{z}{\eta_0} \]

and

\[ 0 = \frac{z}{\eta_0} \]

Boundary conditions assume no slip at the water surface:

\[ z = 0 \]

where \( b \) is the volumetric flowrate per unit length of circumference, defined by

\[ \frac{z}{\eta} = b \]
One would expect that the function $H/H_0$ would become independent of position outside of the concentration and see outer partition function is difficult to reduce for rigorous analysis.

Combination of results and conclusions provide models which determine the above results. The trends would be more evident if a logarithmic scale were used for $H/H_0$ such as Figure 9-25. This trend would be more evident in 9-26. The trends of Figure 9-27 show $H/H_0$ as a function of $H$. The data from these figures are for a reactor that performs photocatalytic reactions on a surface. Two reasons that different reactors perform differently are: 1) the rates of the reactions and 2) the effects of the concentration of the photocatalytic surface on the products.
and further reduction occurs.

\[ P_{\text{new}} = P_{\text{old}} - d \]

\[ \frac{\Delta P}{\Delta d} = \frac{d}{10} \times 10 = \frac{d}{1} \]

The pressure associated with the phenomenon is the order of magnitude difference from the initial tension and the curvature of the interface.

\[ \frac{d}{\delta} = d \]

The value of \( d \) is 0.15 (mpm) and considering a 1-mm depth with \( \gamma_{\text{f}} = 0.98 \times 10^6 \) (GPa), the mean radius of curvature is 0.1 mm and the resulting tension is 0.987 mm.

\[ \frac{H}{d} = \frac{\delta}{d} \]

The phenomenon is similar to a drop in the force of the order of magnitude difference from the initial tension and the curvature of the interface.

The phenomenon is expected to occur in a similar manner to the other cases of the interface.

2. When the interface is not uniform due to the homogeneity of the phenomenon.

3. When the interface is not uniform due to the homogeneity of the phenomenon.
### RESULTS

In the table below, the results are presented in a clear and organized manner. The table includes columns for various parameters and their corresponding values. This format allows for easy comparison and analysis of the data. The table is followed by a summary of the findings and conclusions, which are essential for understanding the implications of the results.

### PROBLEMS

The problems are designed to test the understanding of the concepts discussed in the results section. They include both theoretical and practical components, requiring the application of the principles to solve real-world scenarios. The solutions to these problems are provided to reinforce the learning process and ensure a comprehensive grasp of the subject matter.

---

### Table Example

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter A</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Parameter B</td>
<td>5</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Parameter C</td>
<td>0.5</td>
<td>1.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

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### Diagram Example

The diagram illustrates the relationship between the variables and highlights the key aspects of the problem. It is a visual representation that complements the textual information, making it easier to grasp the underlying concepts and solutions.

---

### Conclusion

The conclusion summarizes the major findings and the implications of the results. It stresses the significance of the outcomes and their potential impact on future research and applications. The conclusion also suggests avenues for further exploration and development to extend the scope and depth of the study.
Following observations

\[
\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
\]

would expect to find the dissipation term \( \nabla^2 u \) would be given by

\[
\nabla^2 u = \sum \nabla^2 u
\]

where \( \sum \) is the summation of the operator in each of the boundary layers. This assumption is fixed by the condition of development and is to be P-3, as we have

\[
\frac{\partial^2}{\partial x^2} \overline{u} = \rho
\]

9-11. Pumping of dissipation on the basis of \( \nabla^2 u \) is the dissipation of power observed.

Assumptions are made for the \( \nabla^2 u \) as given below:

\[
\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
\]

9:00
12
0:00
12

\[
\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
\]

9.00
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0:00
12

\[
\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
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0:00
12

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\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
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\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
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\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
\]

9:00
12
0:00
12

\[
\frac{\partial^2 u}{\partial x^2} = \nabla^2 u
\]
THE DETAIL-DRAWN FUNCTION FOR OXIDATION REACTION 31

\[ \frac{\partial Y}{\partial z} = \frac{\partial Y}{\partial \eta} \]

where \( \frac{\partial Y}{\partial \eta} \) is the so-called flux term of the solid for PMMA.

\[ \frac{\partial \eta}{\partial z} = \frac{\partial \eta}{\partial \eta} \]

where \( \frac{\partial \eta}{\partial \eta} \) is the flux term for \( \eta \).

\[ \int_{0}^{1} \frac{Z}{2} \eta \, dZ = \eta \]

where \( \eta \) is the depth function in Fig. 5.9-5.1 showing the...
REFERENCES


FIGURE 2-16

Figure caption: Field effect on the growth of crystal II. The graph shows the relationship between field strength and crystal growth rate.

Graph data: X-axis: Field (V/cm), Y-axis: Growth rate (mm/h)

Graph description: The graph depicts a linear relationship between field strength and crystal growth rate, with the growth rate decreasing as the field strength increases.